WARM FORMING: A MATTER OF CONTROL

WARM FORMING EXOTIC MATERIALS—FROM TITANIUM TO MAGNESIUM—MAY OPEN UP NEW MARKETS FOR STAMPERS ACROSS THE COUNTRY.

By Phil Walters

Years ago, a steering wheel represented a stamped component. Today, like many other automotive parts, they're made of a magnesium die-cast.

"I think they could be made from a stamping again—if we can form the magnesium," says Denny Boerger, product manager for AIDA-America in Dayton, Ohio.

But forming such sensitive material isn't easy. Magnesium, titanium and high-strength aluminum have excellent strength-to-weight ratios, yet lack formability. But new research findings could change that. A collaboration between The Ohio State University's Engineering Research Center for Net Shape Manufacturing and AIDA-America has produced a successful drawing process on titanium. At the press manufacturer's North American headquarters, the research team performed trials and successfully attained a diameter-to-height ratio of 1:2.1. That's a big stretch, so to speak, for such brittle material. The secret is heat. Researchers heated press tooling to between 100 and 110 C, a temperature that, when transferred to the titanium being drawn, doubled its formability.

Called warm forming, the process takes full advantage of what the metal-forming world didn't have only five years ago: servo-controlled press ram control. Several presses on the market, including AIDA's ServoPro introduced in 2003, replace flywheels with an integrated servo motor that gives users control of the stroke, including dwell times (Figure 1).

"You wouldn't be able to do this on a conventional press," says Boerger. "It's a combination of heating, controlling the slide motion with the servo press and lubrication."

With these factors working together, the process has drawn

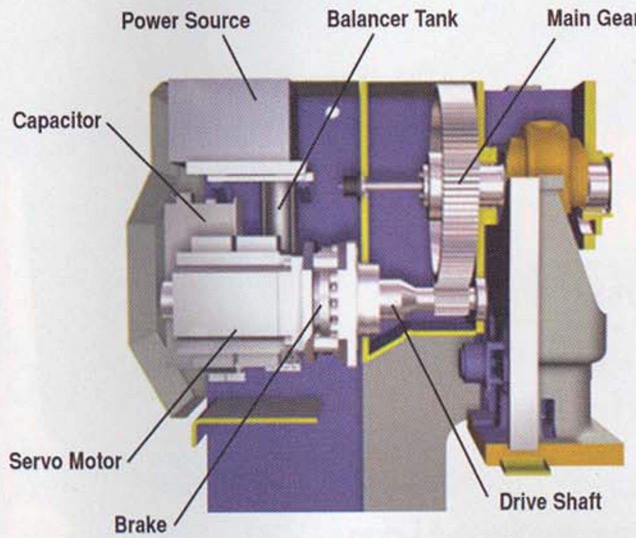

Figure 1—Schematic of AIDA's ServoPro, which can control the speed of the ram stroke on a press.

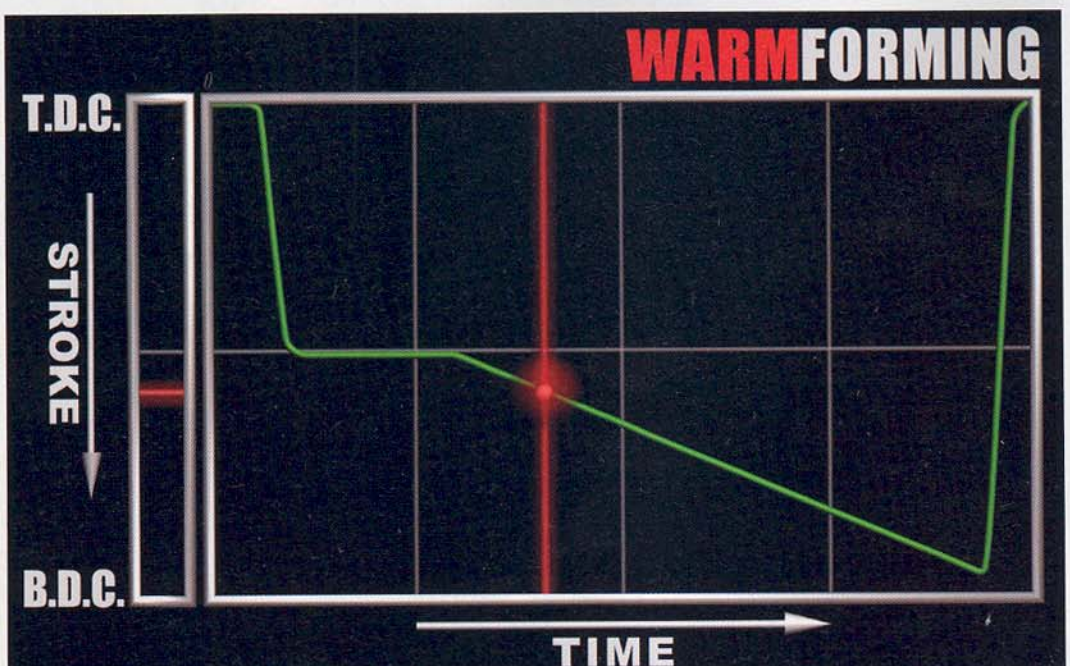

Figure 2—A graphical representation of the warm forming process on a servo-controlled press. The horizontal portion early in the stroke represents press dwell time. (T.D.C, Top Dead Center; B.D.C., Bottom Dead Center)

magnesium casings for high-end computers, magnesium housings for cell phones, along with several other products made by early adopters of technology. And much of the process' success can be attributed to precise control of heat and the slide motion of the press.

TWEAKING THE PROCESS

Exact die temperature is determined by various material properties and, for titanium, to avoid discoloration. For magnesium, the team heated dies to about 300 C.

At that temperature, though, high-temperature lubrication isn't all it's cracked up to be. "The heat caused all the lubricants to be very ineffective," Boerger explains. "One actually turned into a white powder that became very abrasive." So the team turned to a film that could withstand the high-temperature process. A hard insulation material was also used to protect press components from heat and to facilitate efficient heat transfer.

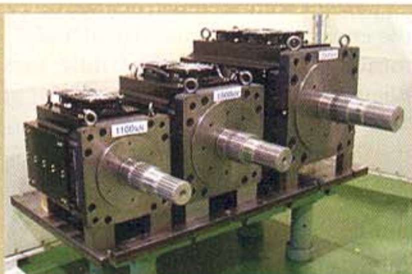

Figure 3—Servo motors used to control the press ram stroke.

To begin the cycle, the slide closes down on the material very quickly, then stops for a predetermined dwell time, anywhere from about one to five seconds, depending on the amount of heat transferred. At this point, slide motion programming comes into play. The machine is told what exact drawing or forming velocity is required. One material might require 50 mm per second, another 60 mm per second (Figure 2).

"The speed is constant through the forming portion of the stroke," Boerger says. "By controlling the velocity, we can control the thinning and thickening of the material during different portions of the form. And by heating and controlling the velocity together, we naturally eliminate the material's tendency to crack."

The end result? A successful draw with a height-to-diameter ratio of 2.9:1—on a magnesium part.

The material flow and, specifically, its thickness throughout the operation is closely monitored. Through computer simulations, it was determined that controlled velocity, among several other factors, is key to preventing material fracture.

"If you form too fast, with blank-holder pressure, for instance, you would tend to get extreme thinning just beyond the radius," Boerger explains. "All that material [pressed at the cup's bottom] has to go somewhere, so naturally it becomes very thick at the top of the drawn part."

Consider a drawn cup. During the operation, the bottom remains a constant thickness, but as soon as the punch comes around the radius and travels up the sidewall, thinning around the radius occurs. "By controlling the slide velocity, we are able to control the level of thinning in the material," he adds. "It's not 100 percent, but it's certainly an improvement."

MUCH OF THE SUCCESS BEHIND WARM FORMING CAN BE ATTRIBUTED TO PRECISE CONTROL OF HEAT AND THE SLIDE MOTION OF THE PRESS.

Contact velocity is carefully controlled, gentle when the press begins to form, as if the tooling is handling the material with kid gloves, being sure not to exceed the metal's tensile strength and cause failure. When about 10 to 15 mm of the magnesium part is formed (the exact distance depends on the material), then the forming velocity increases as the process stabilizes.

Some factors in this process aren't as critical, like blank-holder pressure, which can vary by as much as 10 to 15 percent without much change to the end result. But a mere tweak in forming velocity can cause failure. Says Boerger: "A variation in 5 percent in velocity would considerably change the thinning—and sometimes the success in our ability to make the part without destroying it."

OPENING NEW MARKETS

Comparing the output of a die-casting system and a forming line, the forming line's cycle times would be three to five times faster, Boerger says. If warm forming can meet demands of the auto industry's push toward lighter and stronger material—including, of course, aluminum—the process could open up new markets for stampers worldwide.

"Within five years, I think there will be warm forming in more exotic materials in a number of industries," Boerger says. During past years, researchers have modeled the process, and those models have now been confirmed using an actual press and die. "What was modeled and thought to be the case is, today, really the case. We can now talk about the process with confidence." FM

For more information on warm forming, visit www.aida-america.com and http://nsm.eng.ohio-state.edu.